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Revised title: Adaptive Logistics: Complexity and Adaptation

Presented in (input and Bold one): (**WG19**, CG____, Special Session ____, Poster, Demo, or Tutorial):

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Adaptive Logistics

Complexity and Adaptation

Jeffrey R. Cares
73rd MORSS

Agenda

- Introduction
- Network Fundamentals
- Complex Control Fundamentals
- Sense and Respond Logistics



Introduction

- Adaptive Enterprise/S&R Organization
 - Mostly theoretical
 - No working model
 - Complexity in the footnotes
 - Not fully developed
- Research Effort
 - Translate S&R Theory to the next level of specificity
 - More fully develop scientific basis

Research Areas

- Logistics/Supply Chain Theory
- Adaptive Enterprise/S&R Concept
- Network Flows and Graphs
 - Scale Free Networks (c. 1999-2005)
- Multi-scale Representations
- Diffusion of Innovations
- Social Network Analysis
- Complex Control Theory
- Physics of Information

Every claim in this presentation can be scientifically validated!

Central Ideas

- Exploitable properties of Complex Networks
 - Hubs/Spokes with skew distribution
 - Tipping Points in dynamic structure
- Networks better than chains in complex environments
 - Requisite Variety, Complex Control Theory
- Demand as complex network control signal

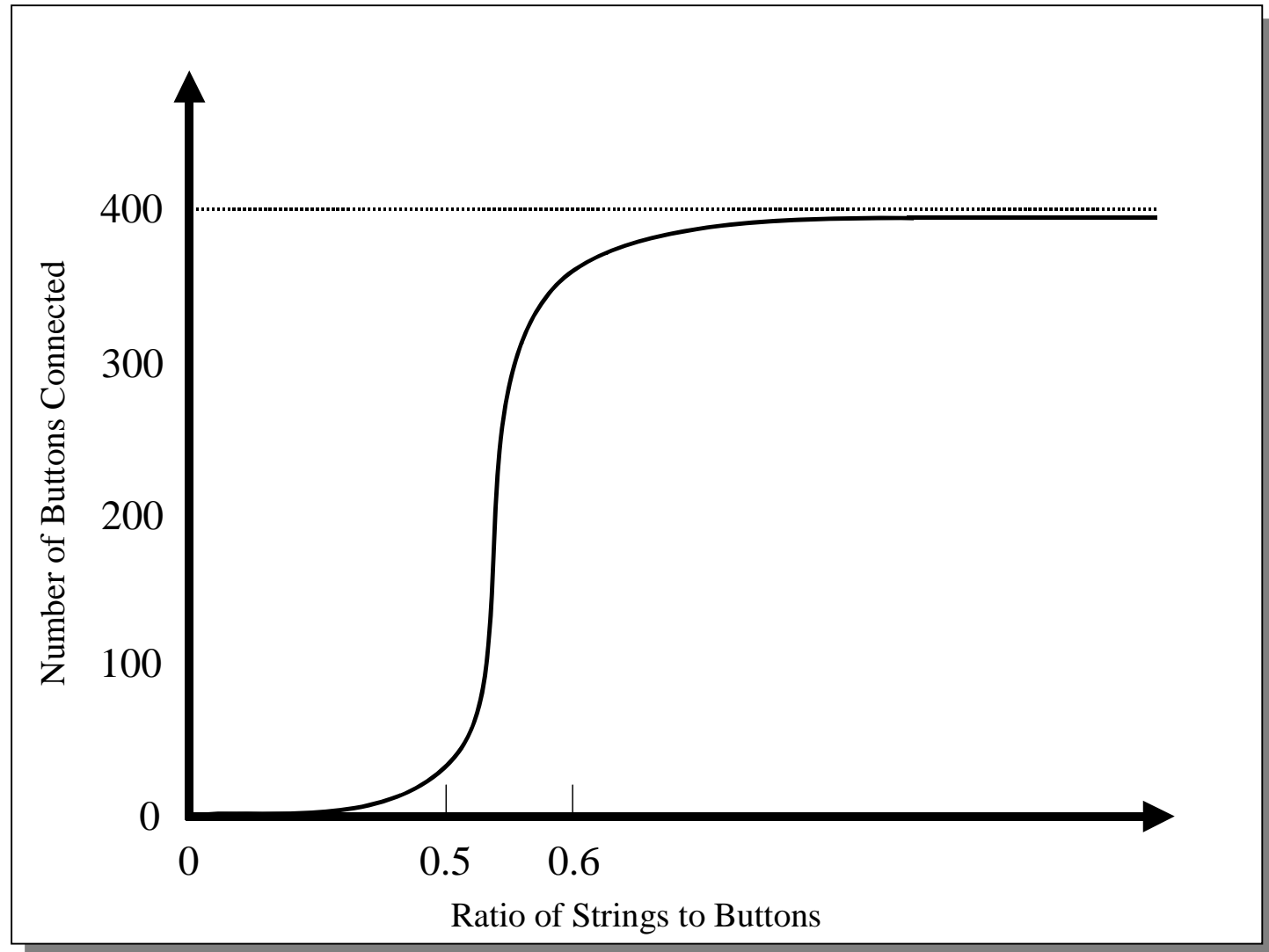
Demand Networks v. Supply Chains



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Adaptation
And
Complexity

Erdős Connectivity Profile

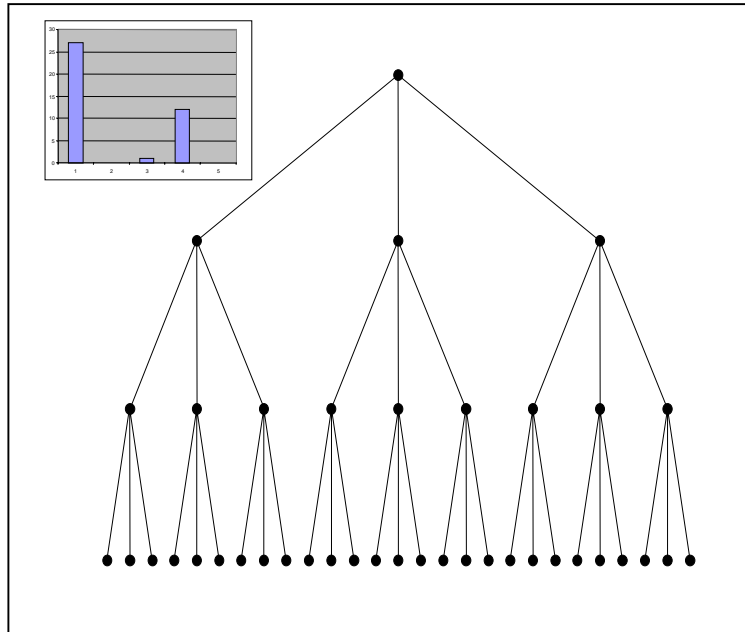




Some Facts About Networks

- Minimally Connected Network
 - Too brittle, long CPL, poor clustering, simple pattern, simple control, scaled
- Maximally Connected Network
 - Robust, short CPL, too clustered, simple pattern, complex control, scaled
- Regular Network (Lattice)
 - Robust, long CPL, high cluster, simple pattern, simple control ($\langle k \rangle < 5$), scaled
- Erdős Random Network
 - Brittle, short CPL, low cluster, random pattern, complex control, scaled
- Small World Network
 - Robust, short CPL, high cluster, complex pattern, complex control, less scaled
- Random Network with Growth
 - Less brittle, short CPL, low cluster, random pattern, complex control, less scaled
- Network with Preferential Attachment
 - Robust, short CPL, low cluster, complex pattern, complex control, scale free

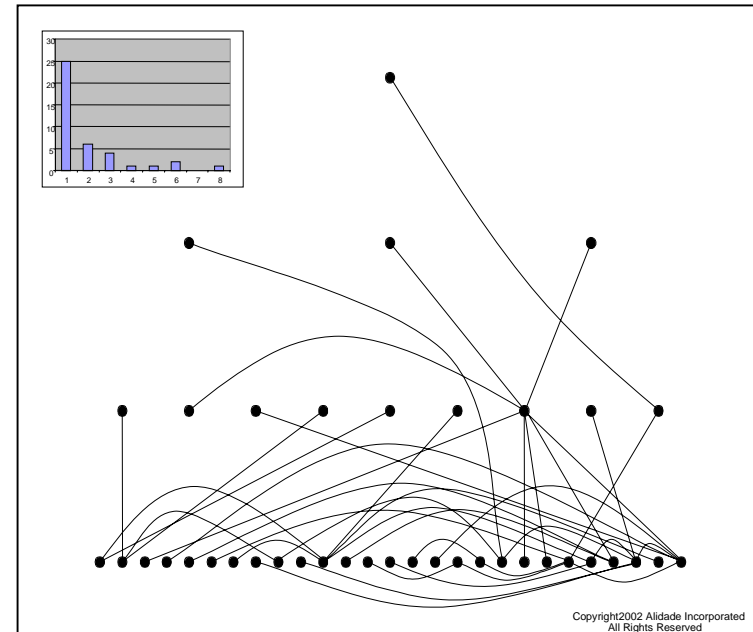
Chains v. Networks



Supply Chain

Too brittle, long paths, low clustering,
simple pattern, simple control, scaled

“business end” most poorly connected,
hard to reconfigure or change flow



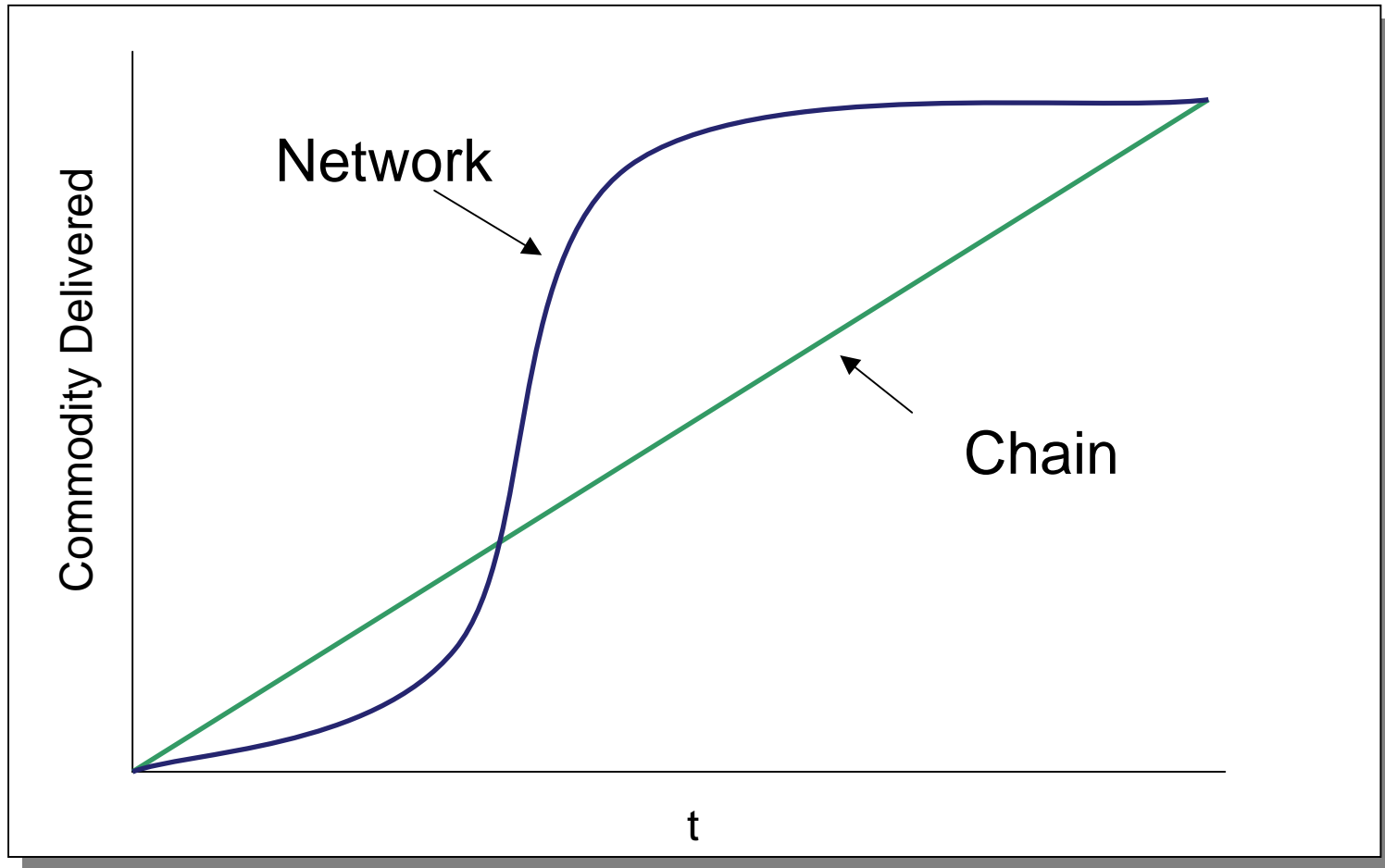
Demand Network

Very robust, short paths, low clustering,
complex pattern, complex control, scale free

“business end” best connected,
natural to reconfigure or change flow

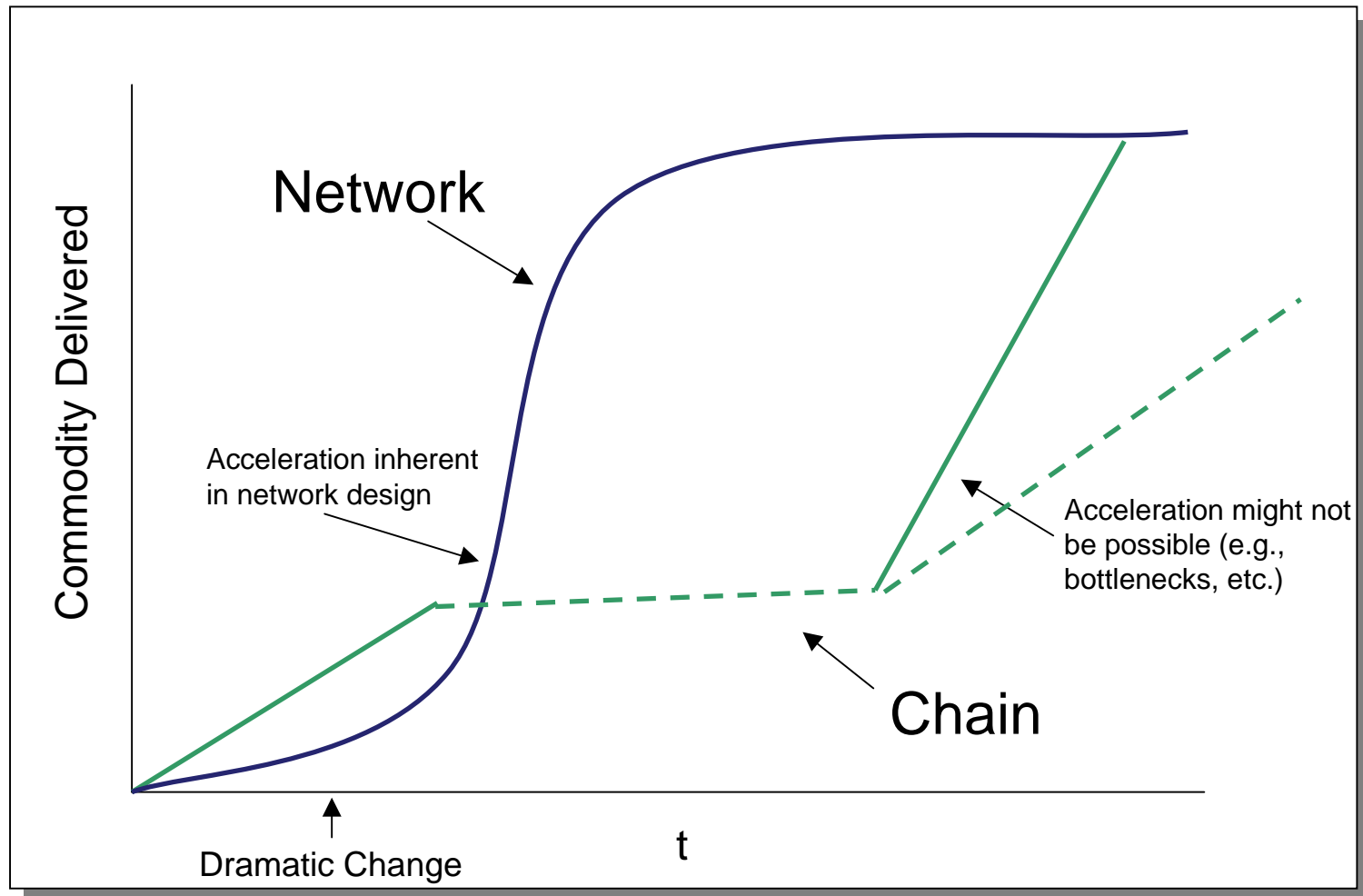
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Chains v. Networks



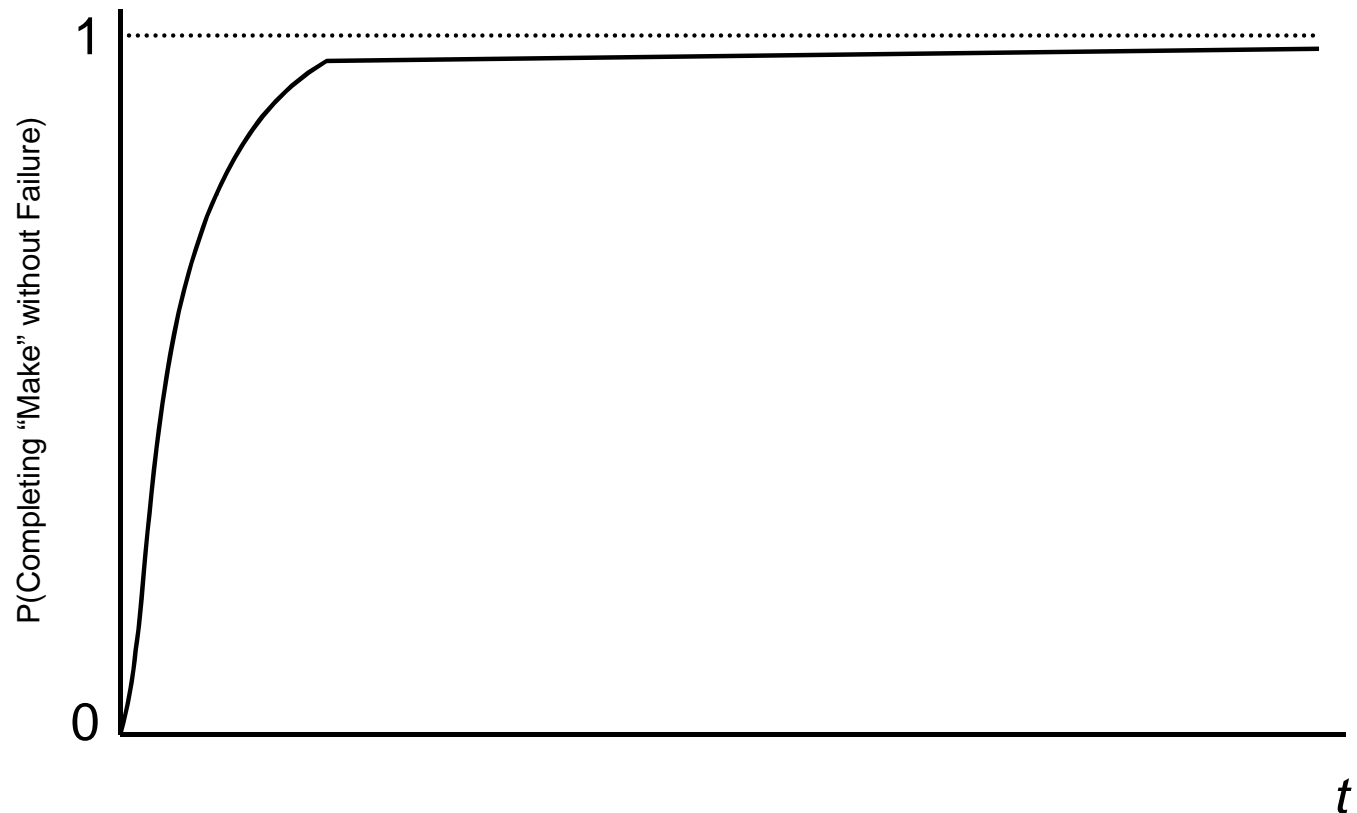
Scale may dramatically affect this comparison

Chains v. Networks w/ Uncertainty



...About Optimization

Makespan and Slack Time



Supply v. Demand

- “Supply” perspective rooted in Industrial Age Logistics
 - Paragon is WalMart Model
 - Focus is on decreasing time or cost of delivery
 - Using IT to refine the supply chain by shortening the chain (disintermediation) and better prediction
 - Still has an upper limit of efficiency
 - Would function poorly under the type of uncertainty and scales we see in combat operations
- “Demand” is the real control signal
 - Closely related to Commander’s Intent
 - Intimately related to unfolding battlefield operations

Supply v. Demand w/ Uncertainty

- Supply process requires great predictability
 - Depends on statistics of stability
 - Lagged reaction to dramatic changes
- Demand
 - We have the best insight on the control signal
 - S&R becomes a “learned response”
 - Enemy has the hardest task of the Information Age: determining our demand signal by observation

Adaptive Logistics

- Demand *Networks* rather than Supply *Chains*
 - Turn units in the main effort into nodes of preferential attachment
 - Quickly reconfigure network and hubs as situation unfolds

Unit-to-Unit (U2U) Logistics with
scale-free units of issue vital (modularity)

Adaptive Logistics

- *Demand* Networks rather than *Supply* Chains
 - Closely tie logistics to operations through Commander's Intent
 - Obscure the intent with a distributed logistics train while operating without a centralized dump
 - Adaptive Learning v. Reactive Planning

Questions?